Figure 2: **A detail of the gearboxes.**

Case study: Bonfiglioli Spa's coating department

Bonfiglioli Spa's plant of Forlì manufactures three main types of product: gearboxes for self-propelled machines (rotation of caterpillars and excavator turrets), electromobility devices and gearboxes for wind turbines (**ref. opening photo**).

Bonfiglioli's customers include the world's leading players in the wind energy and earth moving machinery sectors.

"With clients like these, the coating specifications are very stringent," Nati states. "Together with Bonfiglioli, we carry out all the laboratory tests needed to meet such specifications. Some customers, particularly the major producers of the Agriculture & Construction Equipment (ACE) sector, require us to certify our process and, in this way, they provide guidelines also for the products intended for other buyers.

"Lately, the demands for high quality and performance standards have been constantly increasing. This is a challenge for Pieffeci, but also a spur to improve our work for Bonfiglioli. We have set a very restrictive tolerance limit for non-compliance and, thanks to our control of the coating parameters, we have not had any discarded part for a long time. Our painting results have reached the level required by the most demanding clients thanks to the use of appropriate devices, already present on the plant and updated by us. These include the dosing, mixing and application equipment provided by Graco Distribution BVBA through its distributor AS Divisione Verniciatura (Ozzano dell'Emilia, Bologna) and the high degree of automation brought to the line by Pieffeci thanks to the robots installed by CMA Robotics (Pradamano, Udine)."

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Figure 3: **The two-rail conveyor supplied by Futura Convogliatori Aerei Spa has a maximum capacity of 1250 kg.**

“From the loading to the packaging phase, the process has been automated to be faster and more manageable. The joint management of the painting, packaging and shipping departments offers a further benefit: we control the entire final part of the production cycle and, therefore, we can perform in advance, combine and modify the operations that are typical of each phase to improve overall process efficiency.”

Figure 4: **The cleaning tunnel.**

Pieffeci’s intervention

When Pieffeci entered Bonfiglioli’s plant in November 2009, the situation was very different. Liverani says: “They were particularly worried about the actual production capacity of their manual coating system, which treated no more than 250-300 components while being designed to handle 500 parts per shift. The addition of five CMA robots enabled us to streamline the production cycle, fill the gap and increase its capacity by 40%.”

The automation intervention has involved the whole process, starting from drying (blowing stations), coating and protection of the non-coated surfaces (oiling). The path followed by the gearboxes is monitored at every step. A screen provides visual instructions that are updated according to the workpiece on the line.

“From the loading to the packaging phase, the process has been automated to be faster and more manageable,” Nati explains. “However, the control of the technological management staff remains crucial: although the whole

line is managed automatically and robots receive directions for the programs to run through the identifying barcode with which each part is labelled, the operators can continually check that every automatic operation is performed correctly. Moreover, the joint management of the painting, packaging and shipping departments offers a further benefit: we control the entire final part of the production cycle and, therefore, we can perform in advance, combine and modify the operations that are typical of each phase to improve overall process efficiency."

Figure 5: **The exterior of the painting system, installed by Tecnofirma (Monza).**

Another feature of Pieffeci's work for Bonfiglioli has been the choice to keep using the water-based coatings already selected by the company before the arrival of the Turin-based firm. "The paints are all water-based and supplied by Inver-Valspar," Nati says. "We use the Idroxinver basecoat and the Inverpur/A topcoat; the latter has been chosen because it has a very small percentage of solvent. We use both one-component and two-component products: the former, in most cases, is used for the application of a single primer layer on components that are then finished by the customers. In order to obtain a more durable coating system and higher quality thicknesses, however, we are asking our customers to choose only two-component products."

Figure 6: **The robotic application of the primer.**

Figure 7: **The robotic application of the topcoat.**

Step-by-step monitoring of the coating process

The coating of gearboxes is complex because of the weight and shape of the parts, but also due to the difficulty in evenly protecting their surfaces, exposed to extreme wear and corrosion (**fig. 2**). "Once the material to be handled reaches our department, we assign a barcode to each product, with which we can monitor every step," Liverani says. "In order to reduce the number of colour change operations, we group the components according to the shade to be applied. After preparing the hanging hooks and the masking caps, the cycle begins with the loading of the material. The two-rail conveyor provided by Futura Convogliatori Aerei Spa, with a maximum capacity of 1250 kg, handles parts with different dimensions (**fig. 3**); the weight of each workpiece ranges between 10 kg and 1 ton.

"To remove the oils remaining on the surfaces after the assembly stages, we transfer the parts into a cleaning tunnel performing an alkaline degreasing, a rinse with fresh water, and a rinse with demineralised water and an amine passivating agent that improves paint

adhesion (**fig. 4**). We have installed an ultrafiltration system and an oil separator for the first alkaline degreasing bath, since the gearboxes reach the cleaning phase with a large amount of oil on their surfaces, and an inverse osmosis system for the demineralised water of the third washing stage. This is followed by a double robotic blowing station, where most water is removed, and by an oven, which dries the residual moisture at 70°C. For masking, preparing and arranging the surfaces that do not have to be coated, the operators can see all the operating instructions on dedicated monitors."

Robotic spray paint booths

The coating system includes 4 spray paint booths separated by a flash off tunnel (**fig. 5**). The thicknesses required for this type of product range from 40 to 400 microns in one to four coats; only one system, however, requires the application of a single coat, that of a 40-micron shop primer used if the client is to finish the part. Normally, the first two booths apply the basecoat and the last two the topcoat.

The third one can apply both: in the event of any productive peaks, this enables to allocate the production volumes evenly and keep the takt time constant. The coating robots are installed in the first three booths (**fig. 6 and 7**), while in the fourth one the operator applies the paint manually, in case of small lots or prototypes or for a touch-up if the result of the visual control on a component has not been positive.

The automation of Graco's dosing systems

Bonfiglioli's paintshop is equipped with Graco systems provided by the area distributor, AS Divisione Verniciatura, with which Pieffeci's engineers have established a trusted relationship that has enabled them to constantly develop and implement new and more up-to-date application solutions. "Last August, in Bonfiglioli, we replaced the Promix Auto dosing system of the first booth, used for over ten years, with a Promix 2KS," Gian Luca Casoni from AS says. "It was an unavoidable choice, because Promix Auto's replacement electric components will be soon difficult to find (**fig. 8**). However, this provided the opportunity to install a new, more powerful system ensuring more reliability in terms of both quality and capacity. Together with the staff of Pieffeci and the management of Bonfiglioli, which made the investment, AS performed an assessment of the plant aimed at exploiting its full potential. It was therefore decided to place the mixer inside the booths, unlike the previous arrangement. We have thus reduced the length of the pipes and the amount of catalysed product circulating, as well as improving the use of space (**fig. 9, 10 and 11**)."

Figure 8: **The Promix Auto dosing system previously installed at the Bonfiglioli premises.**

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Figure 9: **The new Promix 2KS dosing system.**

Figure 10: **A detail of the pumps.**

Figure 11: **Promix 2KS's PLC.**

The primer's dosage is managed by 2 Promix Easy systems (**fig. 12**). One is devoted to the standard light grey basecoat and the other to the yellow and black primers required by some specifications to ensure that the surface is protected and the colour remains the same as the rest of the component even in case the topcoat is scratched. "The Promix Easy dosing systems have been installed with a manual handling process in mind," Casoni explains. "When Pieffeci integrated the robots, they could not interact with them. A PLC able to manage the two Promix Easy devices was therefore added: in this way, we turned the two machines into semi-automatic systems able to interact, although in a limited manner, with the coating robots (**fig. 13**)."

The benefits of an automated application process

"Our catalogue includes a range of 60 topcoats," Nati says. "At the moment, the most used ones are 17. These are kept within our coating management unit, in tanks equipped with a stirrer and a pump that are managed by the Promix 2KS dosing system together with the catalyst (**fig. 14**). A "wildcard" pump handles the rest of the colour range by directly drawing the products from the paint drums. We perform checks on the viscosity of the paints and ensure that the temperature and humidity of the heated chamber of the coating management unit are adequate."

Pieffeci has also changed how the product volumes are managed by switching, where possible, from 30 kg to 200 kg drums and consequently installing a few lifters, which has facilitated the work of the staff involved and increased their safety.

"As for the application phase, we use Airmix G 40 automatic guns. The robots have 2 guns each, one for the one-component and

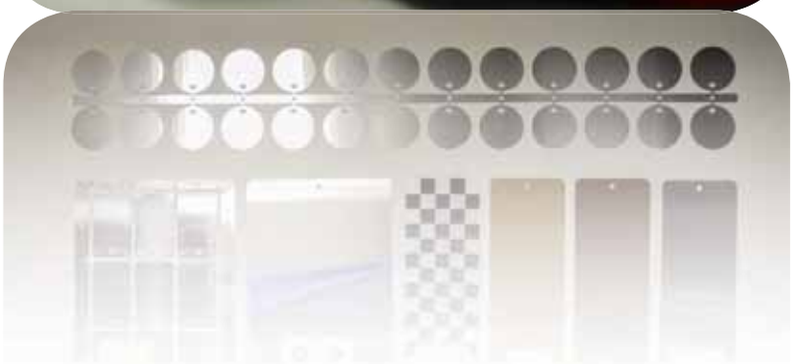
“The waste of paint was halved, while the time needed for the colour change operations was decreased from 75 to 43 seconds. Considering the high number of daily changes, about 40, the benefits are unquestionable.”

the other for the two-component product, with a usage rate of 50% each,” Liverani says. “This choice was motivated by the need to avoid any continuous cleaning and loading operations of the guns. We now have two devices that are always loaded and ready for use.”
“The greatest advantages achieved were the saving in paint and the reduction in the colour change times,” Nati states. “The waste of paint was halved, while the time needed for the colour change operations was decreased from 75 to 43 seconds. Considering the high number of daily changes, about 40, the benefits are unquestionable.”

The protection of the gearboxes

The drying oven installed after the coating plant polymerises the gearboxes’ surfaces for about one hour and a half. The following tunnel cools the workpieces before unloading, so that they can be immediately handled for packaging.
“We always verify that the paint has cooled down and has reached a temperature below 40 °C, so that the gearbox can be positioned on the base of the box with which it will be

Figure 12: The Promix Easy system for dosing the primer.



shipped," Nati states. "In the unloading area, the last monitor of the line shows the operators the number of parts to be placed in the packing unit, with what arrangement, and which packaging unit to use according to the characteristics of the customer (**fig. 15**)."
Before the unloading station, there are an unmasking station to remove the films and tapes that protect the flanges during treatment and an automatic station equipped with a robot for the application of a rustproof oil, useful to prevent the flanges from oxidising. Graco has also been involved in the automation of the protective oil application station.
"Once we installed the robot in this station, the biggest difficulty was related to the choice of the pumps and the type of float," Liverani says. "Also in this case, we relied on Graco for the

Figure 13: CMA Robots' control unit.

Figure 14: The coating management unit.

"The AirPro gun is frequently used in the automotive industry to treat limited surface areas where a high quality level is required. This is a very powerful gun, selected by Pieffeci because the various kinds of oil used have very different viscosities."

development of the best solution. We initially assessed the possibility to apply two different oils with two guns located on the robot's wrist. Due to weight problems, however, we finally installed only one gun, choosing the AirPro type to have the possibility to fine-tune the spray fan and thus be able to apply a minimum amount of well-sprayed product on small parts (about 10-20 cc/min) and a greater amount on the larger ones."
"The AirPro gun," Casoni adds, "is frequently used in the automotive industry to treat limited surface areas where a high quality level is required. This is a very powerful gun, selected by Pieffeci because the various kinds of oil used have very different viscosities. This also complicated the choice of the flow metre checking that the nozzle is not clogged and therefore that the application has taken place, since it is impossible to understand whether the gearbox has been fully coated or not through a visual inspection. After several trials carried out at our test centres, we have mounted proportional valves that regulate the flow and pressure of the product so as to ensure the high variability of the fan amplitude and of the flow rate."

"Our collaboration with Bonfiglioli is solid and will continue in the future. Their satisfaction is proven by their request for our consultancy services also for the design, construction, testing, start-up and management of the coating systems of other production plants."

Conclusions

"In general, we can say that Pieffeci's intervention is convenient for all any company experiencing qualitative and productive efficiency issues, but above all wherever the paint consumption and the number of operators needed for the line are significantly high," Nati states.

“Pieffeci will certainly not stop here: we must continue to spread the idea that a proper surface treatment can be an added value for the Italian manufacturing industry. In order to do so, we need partners like Graco and AS, able to provide adequate support for the updates, implementations and innovations to be introduced in our processes”

“Our collaboration with Bonfiglioli is solid and will continue in the future. Their satisfaction is proven by their request for our consultancy services also for the design, construction, testing, start-up and management of the coating systems of other production plants. This proves that we are working well and that we deliver the results required by the companies with which we are cooperating. However, Pieffeci will certainly not stop here: we must continue to spread the idea that a proper surface treatment can be an added value for the Italian manufacturing industry. In order to do so, we need partners like Graco and AS, able to provide adequate support for the updates, implementations and innovations to be introduced in our processes.”

Figure 15: A finished gearbox.

Bonfiglioli Spa’s gearboxes: the creation of a well-established brand*

Bonfiglioli Riduttori was established on April 16th, 1956 based on the entrepreneurial idea of Clementino Bonfiglioli to make the most of the experience he had gained in the design and construction of gears and gearboxes for the agricultural machines and motorcycles of firms such as Ducati, Gilera and Moto Morini. Its first name was “Costruzioni Meccaniche Bonfiglioli”. During the first years, its production focused on gears for the agricultural and motorcycle field, a driving sector in the industrial fabric of the Bologna area at that time. Towards the mid-60s, there was a profound transformation in the local business environment: the growth of the automated machine industry, especially for the packaging sector, lead the city and its region to becoming the world’s most important district in the field, now called “Packaging Valley”. The company immediately grasped the great opportunity that such an evolution could offer and it began to design and manufacture products that would have soon become market leaders. A two-stage epicyclic gearbox was designed and patented, whose success has remained unaltered for the next fifteen years.
The company grew even further thanks to a careful expansion of its product range and to some important takeovers. In 1975, the acquisition of Trasmital, a Forlì-based company producing epicyclic gearboxes intended for earth moving machines, enabled Bonfiglioli to become a leader in this sector.
Bonfiglioli is now a multinational company with more than 3,600 employees, 21 business branches in 16 countries, exclusive distributors in more than 80 countries, and two major plants in India and Vietnam. It is a leader in the global wind market with a 30% share.
In 2017, the company is going to carry out a 5,000 m^2 expansion of its plant in Forlì, which currently has a 36,000 m^2 wide covered area. This will enable it to implement several logistic processes, a sign that the company’s development continues on the research path that has characterised it so far, thanks to its ability to “look into the future” and to identify always new and innovative markets and growth sources.

*Source: Bonfiglioli Spa